PATENT SPECIFICATION (11) 1 582 640

1 582 640

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B6F CP

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SPECIFICATION NO. 1582640

The following amendments were allowed under Section 29 on 26 October 1986.

Page 1 Line 80 Page 4 Line 89 After striker insert the board being a printed circuit board and the conductive regions having been formed by a conventional printed circuit technique, the keys being arranged electrically in a matrix, the rows (or columns) of the matrix being connected to common drive circuits and the columns (or rows) being connected to common input sensing circuits, the drive connections to the rows being on the opposite surface of the board to the connections to the input sensing circuits, thereby avoiding plated-through connections.

Page 1 Delete Lines 88 and 89 insert Preferably the conductive regions are

Page 3 Line 4 Delete , in the preferred
Page 3 Line 5 Delete embodiments,
Page 3 Line 14 Delete through connec-
Page 3 Delete Lines 15 and 16 insert plated-through connections on the board and
Page 5 Delete lines 22 to 26
Page 5 For Claims 11 and 12 read 10 and 11

THE PATENT OFFICE
30 December 1986

erial and/or on the conductive elastomer, such charge arising from various electrostatic generating mechanisms. When the key is released, the area of contact between the elastomeric material and the dielectric material reduces gradually because of the inevitable small surface irregularities. As the charge becomes more localised, the voltage on the board adjacent to and/or around the capacitance forming elements to provide earth screens thereby giving controlled capacitances to earth determined by the area and layout of the conductive regions on the board.

Preferably the board is a printed circuit board and the conductive regions are formed by the usual printing and etching

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IAN ROBERT PRINCE

(54) IMPROVEMENTS IN OR RELATING TO KEYBOARDS FOR ELECTRONIC CIRCUITS

(71) We, ALPHAMERIC KEYBOARDS LIMITED, a British Company, of Manor Way, Old Woking, Surrey GU22 9JX, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to keyboards for electronic circuits and is concerned more particularly with a keyboard of the kind in which each key, when depressed, moves an electrically conductive element into proximity with two conductive regions on a board of dielectric material so as to effect a capacitive coupling between them.

The electrically conductive element on the key conveniently is a conductive elastomeric member or a conductive surface on an elastomeric member. It is known in a capacitive board to arrange two conductive regions, between which a capacitive coupling is to be effected, on the same side of a board facing the conductive element of an associated key. The conductive element, if it was moved directly down onto the board so as to contact the conductive elements, would effect resistive coupling between them. It is known therefore to provide a thin layer or dielectric material either over the fixed conductive elements or over the movable conductive element to ensure that the coupling is capacitive. This however introduces further problems when elastomeric strikers are employed. If a key is hit very hard and/or very frequently, charge can build up on the surface of the dielectric material and/or on the conductive elastomer, such charge arising from various electrostatic generating mechanisms. When the key is released, the area of contact between the elastomeric material and the dielectric material reduces gradually because of the inevitable small surface irregularities. As the charge becomes more localised, the voltage increases and this voltage may build up to a magnitude such that it gives rise to a pulse sensed by the electronic circuitry. Various techniques for overcoming this problem are described in our earlier Patent No. 1443174, involving the provision of further conductive areas on the striker or on the dielectric material on the conductive regions.

The present invention is directed to a new approach to the problem and providing a simpler construction for a capacitive keyboard and giving rise to other benefits.

According to the present invention there is provided a keyboard comprising a board of dielectric material, a plurality of keys, each carrying a conductive striker movable towards and away from the board, first and second conductive regions on the board associated with each striker, the first conductive region being on the same side of the board as the striker and the second conductive region being on the opposite side of the board, both regions being under the associated striker but there being substantially no overlap of the first and second regions, and electrical connecting means connecting one of said first and second conductive regions to the output of a drive circuit and connecting the other of said first and second connecting means to the input of a sensing circuit, whereby operation of a key to move a striker towards the board effects capacitive coupling between the first and second regions via the conductive striker. One or more further conductive regions may be arranged on the board adjacent to and/or around the capacitance forming elements to provide earth screens thereby giving controlled capacitances to earth determined by the area and layout of the conductive regions on the board.

Preferably the board is a printed circuit board and the conductive regions are formed by the usual printing and etching

technique. Alternatively, but less preferably, the conductive regions may be formed by a conductive material applied to a board of dielectric material by a suitable technique. Such a conductive material may be carbon loaded epoxy resin.

The board may have a further conductive region on the same side of the board as said first conductive region over said second conductive region and spaced from said first conductive region.

The striker preferably is elastomeric and, in this case, may be of conductive elastomeric material or of elastomeric material with a conductive lower face.

In capacitive keyboards it is the usual practice to arrange the keys electrically in a matrix, the rows (or columns) of the matrix being connected to common drive circuits and the columns (or rows) being connected to common input sensing circuits. Typically there might be four to eight rows driven by a drive having a corresponding number of phases, which drive applies pulses in sequence to the row circuits under the control of a clock. A separate sensing circuit may be provided for each column or a single sensing circuit may be arranged to sense the various columns in sequence also under the control of the clock so that the timing of any sensed output identifies the particular key which has been operated. Such an arrangement may conveniently be used in the keyboard of the present invention. With the present arrangement, there is no requirement for a layer of dielectric material over the conductive regions or over the conductive striker since, when the further conductive region is present, even if the striker makes direct electrical contact with the first and the further conductive regions, this will not affect the operation of the circuitry since the resistive coupling of these regions does not complete a D.C. path between two drive circuits or between a drive circuit and a sensing circuit. Considering a sensing circuit using an MOS device, the resistive input impedance of this device can be ignored in designing a capacitive key switch. The input to the sensing circuit is effectively connected to the junction of two capacitances forming a capacitive potential divider between earth and the output of row drive circuit. Some stray capacitance to earth is inevitable but, in preferred arrangements of the present invention, this capacitance to earth can be carefully designed into a printed circuit board and thus can be closely controlled. In particular conductive regions forming earthed screens may be provided on the printed circuit board adjacent to and/or extending around the capacitive elements on the board. Thus the capacitances to earth are determined by the arrangement and areas of the conductive regions on the printed circuit board. The other capacitance of the potential divider is formed by the key switch and, in the preferred arrangement of the present invention including the further conductive region, additionally includes a fixed series capacitance represented by the capacitance between the second conductive region on the lower side of the printed circuit board and the further conductive region on the upper side. In the case where the further conductive region is not used, this other capacitance of the potential divider additionally includes a variable series capacitance represented by the capacitance between the second conductive region and the conductive element moved by the key. There will also be a small capacitance between the second conductive region and the first conductive region, which will set the minimum series capacitance between the row drive circuit and the sensing circuit. Some series capacitance between the output of the row drive circuit and the input of the sensing circuit is essential to prevent cross-coupling of the row drive circuits when more than one key per column is depressed. By the arrangement of the present invention this capacitance is constituted by the dielectric of the printed circuit board and the conductive regions on the two surfaces thereof. It is readily possible to arrange that this capacitance is of a suitable magnitude by choice of the surface areas and layout of the conductive areas.

Preferably an earth screen is provided adjacent the second conductive region on the lower surface of the printed circuit board, the earth screen extending partially under the first conductive region on the upper surface.

There may be provided on the board, for the connection of an anti-phase drive signal, another conductive region capacitively coupled to that one of said first conductive region or said second conductive region which is connected to the sensing circuit. For example said other conductive region may be provided on the underside of the circuit board under said first region and spaced from the second conductive region on the board by the earth screen, this other conductive region being connected for feeding with anti-phase row drives in the case that row drive signals are applied to the second conductive region. Alternatively, in the case where the second conductive region is connected to the sensing circuit, this other conductive region can be positioned adjacent this second conductive region. This other conductive region may be substantially smaller than the other conductive regions but, with the anti-phase row drive input, is used to reduce or cancel the effects of stray coupling between the aforesaid first conductive region and the second conductive on the

lower surface of the printed circuit board.

It will be seen that the various capacitances can readily be accurately controlled in magnitude since they are, in the preferred embodiments, formed by printing on the circuit board and it becomes possible to produce a capacitive type keyboard without any layer of dielectric material over the conductive regions on the upper surface of the board. There is moreover a further very significant advantage in that the row drive is now on the opposite surface of the board to the connections to the sensed inputs; this avoids any necessity for through connections on the board (plated-through connections in preferred embodiments) and thereby effects further significant economy with added simplicity to the construction. The built-in small series capacitance between the row drive input conductor and the aforesaid second region on the upper surface of the board has further significant benefits as a result of reducing and controlling the effective "swing" of the variable key capacitance. Firstly this markedly improves the translation of the sensing circuit's electrical hysteresis into mechanical hysteresis which is highly desirable in keyboards. Secondly the maximum drive signal is limited thereby eliminating possible overload of sensing amplifiers and resultant voltage swings causing cross-coupling. It is known for both voltage sensing and current sensing (virtual earth) amplifiers to suffer from this problem. Thirdly, and as a result of the limiting effect described above, the built-in series capacitance between the row drive conductors and the aforesaid second regions on the upper surface of the board allows the use of considerably more drive and/or sensitivity which in turn further improves the mechanical hysteresis and enables the striker to be sensed at a further distance away from the board than has heretofore been possible thereby further simplifying the mechanical construction of the keys.

The following is a description of preferred embodiments of the invention, reference being made to the accompanying drawings in which:—

Figure 1 is a diagrammatic section through a striker of a key and the adjacent printed circuit board in a keyboard;

Figure 2 is a diagram illustrating the electrical arrangement used with the construction of Figure 1;

Figure 3 is a diagrammatic section through a striker of a key and the adjacent printed circuit board in another keyboard; and

Figure 4 is a diagrammatic section through a striker of a key and the adjacent printed circuit board in a further keyboard.

Referring to Figure 1 there is shown diagrammatically part of a keyboard comprising a striker 10 formed of an elastomer with a conductive lower face 17, which striker is movable downwardly on depression of a key (not shown) towards a printed circuit board 11. This printed circuit board, on its upper surface, immediately underneath the striker, has a conductive region 12 (constituting a first conductive region of the invention) which is connected to an input of a sensing circuit and a conductive region 13 (constituting a further conductive region of the invention) which is not connected to any external circuit. On the underside of the printed circuit board 11, opposite the conductive region 13, is a conductive region 14 (constituting a second conductive region of the invention) which is connected to a row drive input circuit. Underneath part of the conductive region 12 and preferably as close as possible to the conductive region 14 is an earth screen 15. This lies between the conductive region 14 and another conductive region 16, smaller than the others, which is connected to an anti-phase row drive input.

The circuit arrangement is shown diagrammatically in Figure 2. In this figure there are shown four row drive inputs 21, 22, 23 and 24 and four key capacitances 25, 26, 27 and 28 energised respectively by the four separate row drives of the keyboard. These four key capacitances constitute one column of a matrix. The four row drives are effectively connected to the key capacitances by further capacitances 31, 32, 33 and 34, these being constituted by the capacitance between the aforementioned regions 13, 14 under each of the strikers. The key capacitances are shown as variable capacitances in Figure 2; they are constituted by the capacitances between conductive regions 12, 13 and will depend on the proximity of the striker 10. The outputs from the various key capacitances in the column are commoned and fed to a sensing circuit 35 which is typically an MOS device. There is a capacitance between the sensing circuit input and earth and this is illustrated diagrammatically at 36. Such capacitance however can be controlled, as previously described, by the provision of an earthed screen or screens formed by conductive regions on the printed circuit board. The antiphase inputs described above are indicated diagrammatically by the anti-phase input circuit 37 feeding through a capacitance 38 to the sensing circuit input. Capacitance 38 is constituted by elements 12 and 16 of Figure 1 and is controlled in the same way. Further capacitances, such as those shown in dotted lines, e.g. at 39, are also determined by the layout of the printed circuit board. A typical keyboard might have up to 18 columns and have four rows, the rows being energised by pulses applied to the row inputs in sequence in a cycle time of about 2 milliseconds.

Either separate sensing circuits are used for each column or a time-shared multiplexing system is employed, the various outputs being sampled for a short period, typically a few microseconds, conveniently just after the falling edge of the row drive pulses.

In Figure 3 there is shown an arrangement similar to that of Figure 1 comprising the conductive regions 12, 14, 15 and 16 on the printed circuit board 11, but omitting the conductive region 13. This reduces the overall residual capacitance between regions 12 and 14 when the key is up, but has an insignificant effect on the maximum capacitance obtained when the key is depressed since the flexible nature of the striker will permit the conductive lower face 17 to come into intimate contact with the upper surface of the board 11 above conductive region 14.

Whereas the arrangements in Figures 1 and 3 have their conductive regions 14 connected to the output of a row drive circuit, and their conductive regions connected to the input of a sensing circuit. If desired, a keyboard can be designed for use with the sensing circuit connected to conductive region 14, and the drive circuit connected to conductive region 12. However, if an anti-phase row drive input is used, this must couple to conductive region 14 for example as shown in Figures 4 and 5.

In Figure 4 the conductive region 14 is connected to the input of a sensing circuit and an anti-phase row drive signal is applied via conductive region 20 adjacent region 14 but remote from the conductive region 15 acting as an earth screen. If desired, the conductive region 13, when present, can be striped with the direction of the stripes being at right angles to the direction of the gap between regions 12 and 13. Alternatively, conductive region 13 can be in the form of a multiplicity of dots. This is to avoid false switching in the event that the edge of the striker connects regions 12 and 13 and bounces before the striker becomes fully pressed down onto the board.

In Figure 5 instead of the conductive region 20 on the lower side of the board 11 there is provided an equivalent conductive region 18 on the upper side of the board. The conductive region 18 may be positioned over the interconnecting strips 19 linking those conductive regions 14 connected to a common sensing circuit. If desired, the conductive region 13 can be omitted from the embodiments shown in Figures 4 and 5 as it is in the embodiment of Figure 3.

It will be seen that the arrangement described above utilises a very simple form of construction for the keyboard, avoiding any necessity of a layer of dielectric material over the printed circuit board or over the conductive element of the striker and avoiding the necessity for plated-through connections on the printed board.

WHAT WE CLAIM IS:—

1. A keyboard comprising a board of dielectric material, a plurality of keys, each carrying a conductive striker movable towards and away from the board, first and second conductive regions on the board associated with each striker, the first conductive region being on the same side of the board as the striker and the second conductive region being on the opposite side of the board, both regions being under the associated striker but there being substantially no overlap of the first and second regions, and electrical connecting means connecting one of said first and second conductive regions to the output of a drive circuit and connecting the other of said first and second connecting means to the input of a sensing circuit, whereby operation of a key to move a striker towards the board effects capacitive coupling between the first and second regions via the conductive striker.

2. A keyboard as claimed in claim 1 wherein the board has a further conductive region on the same side of the board as said first conductive region over said second conductive region and spaced from said first conductive region.

3. A keyboard as claimed in either claim 1 or claim 2 wherein there is provided on the board, for the connection of an anti-phase drive signal, another conductive region capacitively coupled to that one of said first conductive region or said second conductive region which is connected to the sensing circuit.

4. A keyboard as claimed in claim 3 wherein said first conductive region is connected to the sensing circuit and wherein said another conductive region is on the opposite side of the board to said first conductive region and is disposed under a part of said first conductive region.

5. A keyboard as claimed in claim 3 wherein said first conductive region is connected to the sensing circuit and wherein said another conductive region is on the same side of the board as said second conductive region and is disposed alongside said second conductive region remote from said first region.

6. A keyboard as claimed in claim 3 wherein said second conductive region is connected to the sensing circuit and wherein said another conductive region is on the same side of the board as said first conductive region and is disposed alongside but spaced from that region of the board contacted by the striker and close to the second conductive region for coupling anti-phase drive signals to said second conductive region.

7. A keyboard as claimed in claim 3

wherein said another conductive region is on the same side of the board as said first conductive region and is disposed over a conductive region interconnecting said second conductive region with an adjacent second conductive region connected to the same sensing circuit.

8. A keyboard as claimed in any one of the preceding claims wherein there is at least one conductive region arranged on the board adjacent to and/or around one or more of the previously mentioned conductive regions to provide an earth screen or screens.

9. A keyboard as claimed in claim 8 when dependent upon claim 4, wherein there is a said conductive region provided as an earth screen between said second conductive region and said another conductive region and being disposed under the remaining part of said first conductive region.

10. A keyboard as claimed in any one of the preceding claims wherein the board is a printed circuit board and the conductive regions have been formed by a conventional printed circuit technique.

11. A keyboard as claimed in any one of the preceding claims wherein said striker is arranged to strike directly against said first conductive region.

12. A keyboard substantially as hereinbefore described with reference to and as shown in Figures 1 and 2, or Figures 1 and 2 as modified in accordance with either Figure 3 or Figure 4, of the accompanying drawings.

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1582640 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

FIG. 1.

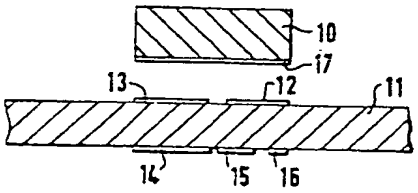

FIG. 2.

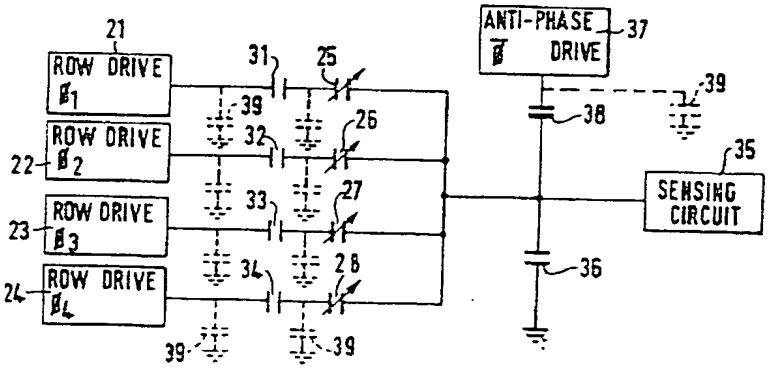

FIG. 3.

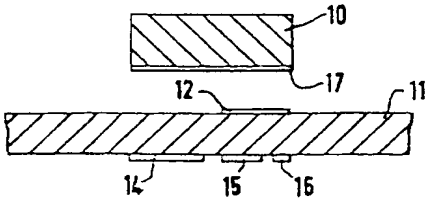

FIG. 4.

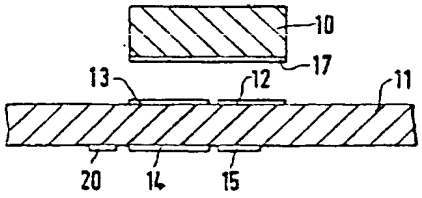

FIG. 5.